BULLETIN OF
THE NEW YORK ACADEMY
OF MEDICINE

VOL. 60, NO. 5 JUNE 1984

CHANGES IN CARDIOVASCULAR EPIDEMIOLOGY SINCE 1950*

MANNING FEINLEIB, M.D.
Director, National Center for Health Statistics
Hyattsville, Maryland

CHANGES in cardiovascular mortality and risk factors during the last 30 or 40 years are among the remarkable health advances of our time. Mortality has declined dramatically for almost all causes of death since 1950. The decline in cardiovascular mortality is at least that old, and continued from the early 1950s to about 1970, when mortality from most other causes was essentially flat.[1-3] Since 1950, age-adjusted cardiovascular mortality has declined by almost 38%; the comparable drop for all other causes was about 21% (Figure 1).

Since the late 1960s mortality from practically all types of cardiovascular diseases has declined at an ever accelerating rate. Age-adjusted stroke mortality fell 40% between 1968 and 1979. What is most remarkable is the abrupt reversal, starting about the mid-1960s, of the upward trend in

*Presented as part of a Symposium in Honor of Duncan W. Clark, M.D., *Themes and Trends in Public Health*, 1943-1982 held at the Downstate Medical Center of the State University of New York May 24, 1983.

Address for reprint requests: National Center for Health Statistics, Federal Center Building No. 2, Room 2-19, 3700 East West Highway, Hyattsville, MD 20782

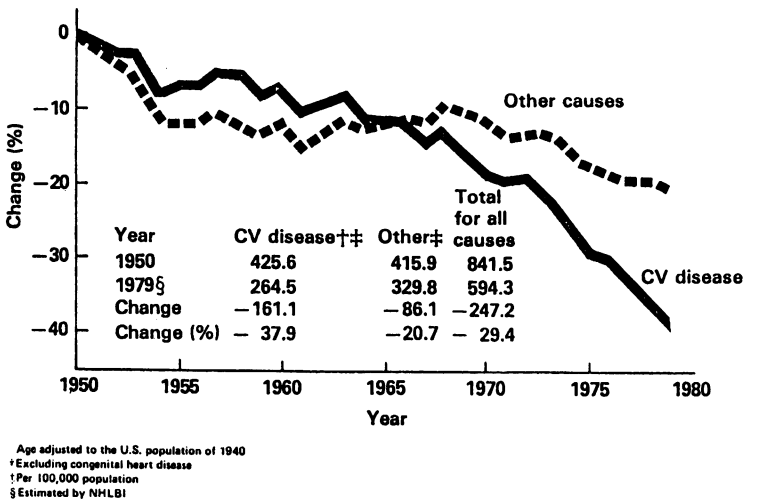

Fig. 1. Decline in death rate for CV and non-CV disease since 1950.

deaths from coronary heart disease. While the decline in stroke mortality goes back at least to the 1930s or 1940s, both the incidence of and mortality from coronary heart disease had been increasing at least through the early 1960s. Since 1968, age-adjusted mortality from coronary heart disease has fallen by 27% (Figure 2).

No similar disease has shown so striking a change in trend in such a short period of time. The decline in mortality from coronary heart disease affected every age, race, and sex group, and the uniformity of the decline is reflected in persistent geographic differentials in mortality. For example, among white men death from heart disease occurs most often in the eastern United States, particularly the South Atlantic states, and least often in the mountain states. This pattern has persisted for at least a decade. Among women, mortality tends to be higher in the northeastern than in the southeastern Atlantic states. The mountain and great plains states still enjoy the lowest mortality rates.

The impact of this decline both as rates and as numbers of deaths is phenomenal. Figure 3 shows what the toll from coronary heart disease would have been in the United States for the population aged 25-64 years if the death rates of 1968 had continued for another 10 years. Because the population is growing, the number of deaths would have risen from about 175,000 to nearly 200,000 each year. Instead, by 1978 coronary heart disease caused just over 140,000 deaths annually in this age group, a

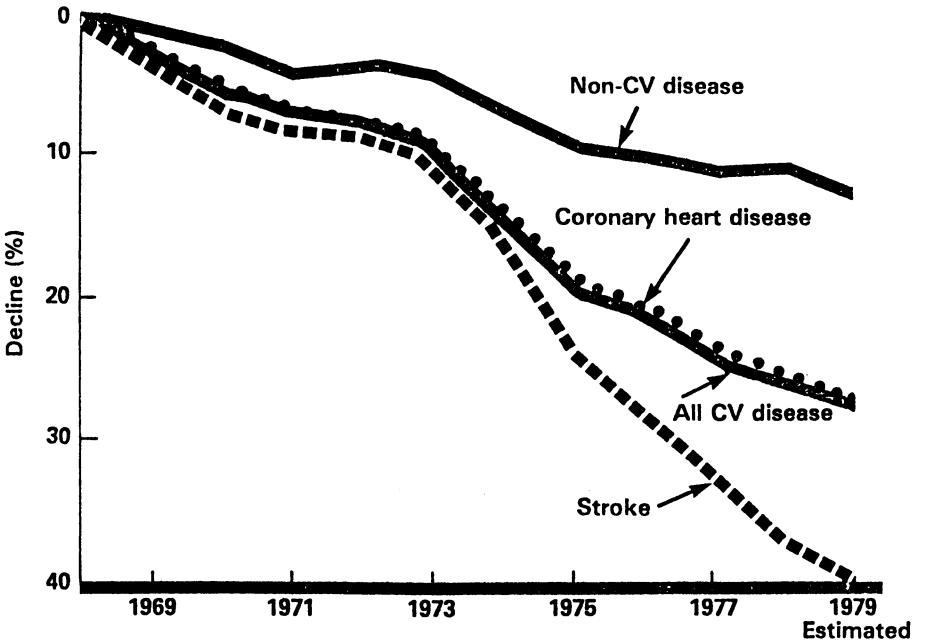

Fig. 2. Age-adjusted death rate for CV and non-CV disease since 1968

remarkable difference from the projected 200,000. In all, during this decade there were 280,000 fewer premature deaths from coronary heart disease than would have been expected on the basis of the 1968 rates.

The decline in heart disease rates in the United States is far in excess of what is occurring in most other parts of the world. Data from 26 countries are plotted in Figure 4 to compare 1978 mortality rates against the 1968 rates for heart disease among men 35-74 years old.[4] Only four countries, the United States (circle number 1 in the figure), Australia (circle number 2), Japan (circle number 3), and Israel (circle number 4) had reported declines of 20% or more. The United States has moved from the second or third highest rate of heart disease mortality, a position it held for many years, to about eighth place among these countries. This is still fairly high, but better than just a decade ago.

Ten years after the general acceptance of the decline in coronary heart disease as a fact, it still is impossible to say with certainty why it is occurring. Analysis has been compounded by problems that begin with the collection and classification of information on causes of death and range to persistent but still unexplained geographic variations.

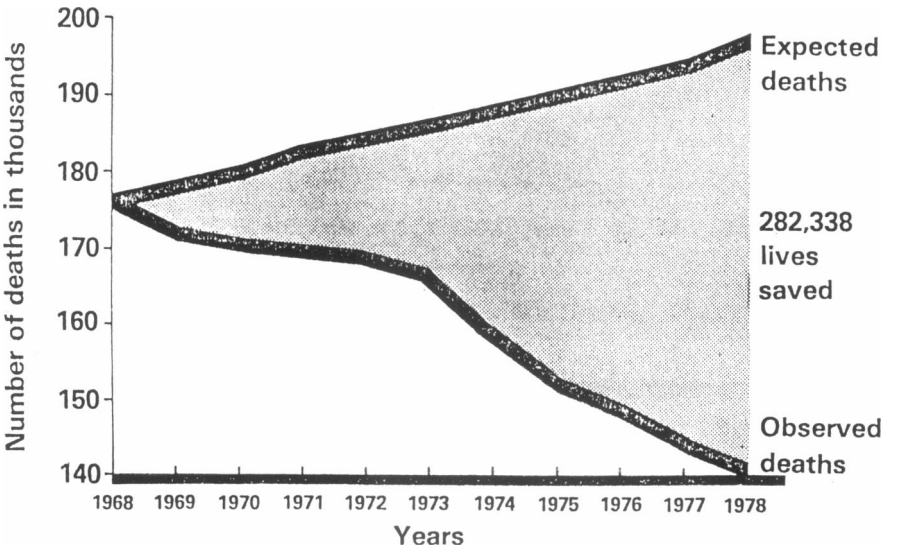

Fig. 3. Lives saved due to reduction in CHD mortality, 1968-1978, ages 25-64

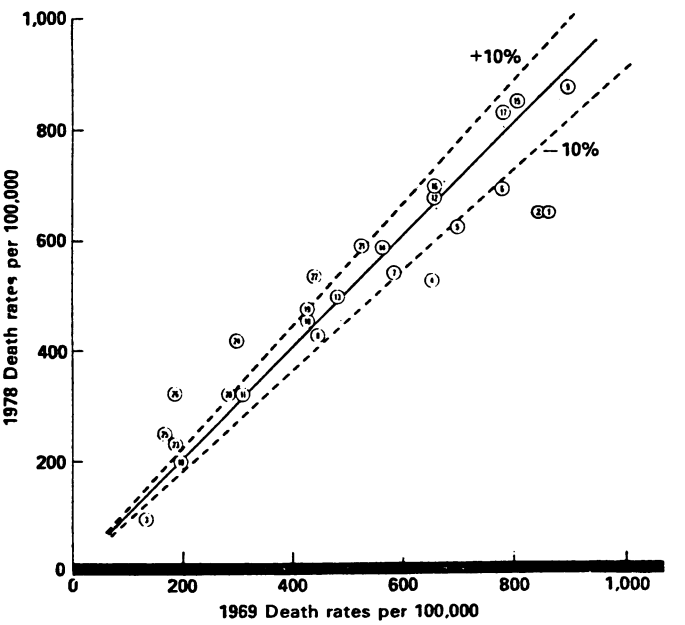

Fig. 4. Death (1969 and 1978) rates for coronary heart disease in males aged 35 to 74 years by country

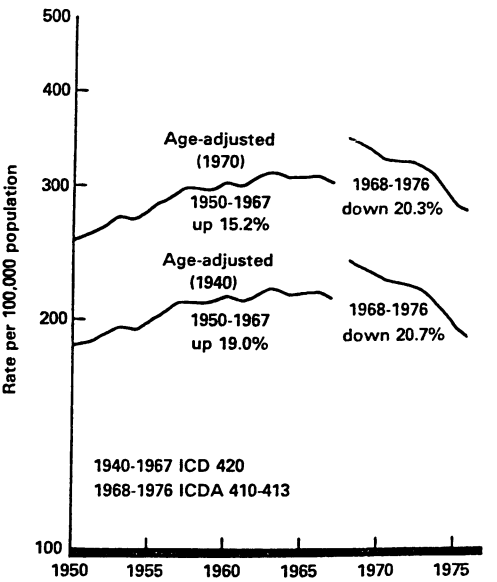

Fig. 5. Age-adjusted death rates for coronary heart disease adjusted to 1940 standard and to 1970 standard. United States, 1950-1976

One key question that contributed to difficulty in initial analysis of the trend was: Is the change in coronary mortality real or is it an artifact of the data?

To study trends in mortality, rates are adjusted to compensate for differences in the age distribution of the population over time. Figure 5 illustrates that the decline is not an artifact of how data are adjusted and, by implication, of how deaths are counted and attributed. It shows two different curves. One is age-adjusted to the population in 1940, the standard reference population used by the National Center for Health Statistics in producing the national vital statistics. The other curve is age-adjusted to the population in 1970. The population has aged since 1940 so that the overall rate is about 50% higher according to the 1970 standard than according to the 1940 standard. But the trends are clearly similar.

Another related problem is the break in the curve at 1968, when the 7th Revision of the International Classification of Diseases was retired and the 8th Revision implemented. After 1968 deaths from hypertensive disease were combined with deaths from ischemic or coronary heart disease when both appeared on the death certificate. Coronary death rates seemed to be higher after 1968 because of this manipulation when in fact they were lower.

HOSPITALIZATION FOR ACUTE MYOCARDIAL INFARCTION, 1970-1981

Year	*Discharge rate/10,000 population*	*Fatality rate (%)*
1970	16.9	25.8
1973	16.9	21.4
1975	18.2	19.3
1977	18.9	19.1
1979	19.4	19.9
1981	20.4	16.3

Two separate phenomena may be at work in the decline in heart disease mortality: either a change in the incidence of coronary heart disease or a change in the case fatality rate. If the incidence of the disease decreases and other factors remain the same, we would expect the death rate from the disease also to decrease. If the incidence remains constant or even increases but more people survive the disease, the cure rate will increase and mortality will decline. Phenomena changing the incidence differ from those changing the case fatality rate. Knowing which are operative has important implications for how we devote our resources and energies in medical care, prevention, and research.

Unfortunately, this country has no method or system for standardized complete reporting of new myocardial infarctions and no incidence data representative of the national population. Available evidence about a possible decline in the incidence of acute myocardial infarction is still debated.

Data from the National Hospital Discharge Survey conducted by the National Center for Health Statistics are frequently used to approximate incidence. For 1970-81 discharge rates from hospitals per 10,000 population for acute myocardial infarction actually increased by over 20% (see table).[5] Despite a declining mortality rate, discharge rates increased. The case fatality rate fell by about one third. These data suggest that prevention may have been less important in the decline in heart disease mortality than the greatly improved survival from heart attacks achieved through our modern technological armamentarium. However, these data are not consistent with data from other sources and so are open to question.[6,7]

In addition, interpretations of data vary. Although discharge rates for most conditions, including acute myocardial infarction, increased during 1970-81, myocardial infarctions showed one of the smallest percent increases among all the diseases categorized. Thus, the increase in dis-

charges for acute myocardial infarction might be interpreted as part of a general increase in use of hospitals. For men and women younger than 65, discharge rates remained essentially stable (Figure 6). Older men and women had an important increase in discharges for acute myocardial infarction. Is this increase real or does it reflect greater use of medical services or treatment of milder cases diagnosed in the elderly population?

The case fatality rate, again from the Hospital Discharge Survey shown in Figure 7, among younger men and women has declined. For women the decline is more than 50%. Decline also is marked in the older group. The main question in interpreting these data is whether the severity of the infarctions admitted to hospitals has remained constant over the years. Very probably the tendency has been to admit cases earlier during their course, perhaps with less clear indication that a myocardial infarction has occurred. In the past, these cases might not have been admitted but sent home to rest for a few days. If later electrocardiograms indicated a past myocardial infarction, it was thought of as silent. Thus, it is not clear whether the decline in the case fatality rate is real or due to the changes in standards for admitting patients to hospitals.

One source of incidence data for a specific population is the DuPont Company, which has an excellent statistical department and has followed the experience of its male employees, a population that ranged between 75,000 and 94,000 during the period 1957 to 1979. According to the DuPont data provided by Dr. Sidney Pell,[8] acute myocardial infarctions declined from 3 per 1,000 employees to 2.5 per 1,000 during the 20-year period, a marked contrast to the increase in hospital discharges. The age-adjusted incidence for the DuPont employees, shown in Figure 8, is extremely variable because even a work force of 80,000 at any particular time is too small to provide stability to any one year's data. However, when one looks at the regression line over the full 20 years there appears to be a continuous decline over the entire period and no sudden break, as was seen in the national mortality data for this period.

As with the incidence, the DuPont case fatality data (Figure 9) give a different impression from the hospital discharge data. Their total 30-day case fatality rates show essentially no change at all from 1957-76 in the survival rate for myocardial infarctions. Whatever decline in the mortality rate there may have been occurred only in the past six years or so of that period. The same picture emerges for the first 24 hours following the attack, essentially no improvement in survival rate during the first 20 years of their experience. Among those who lived the first 24 hours, a

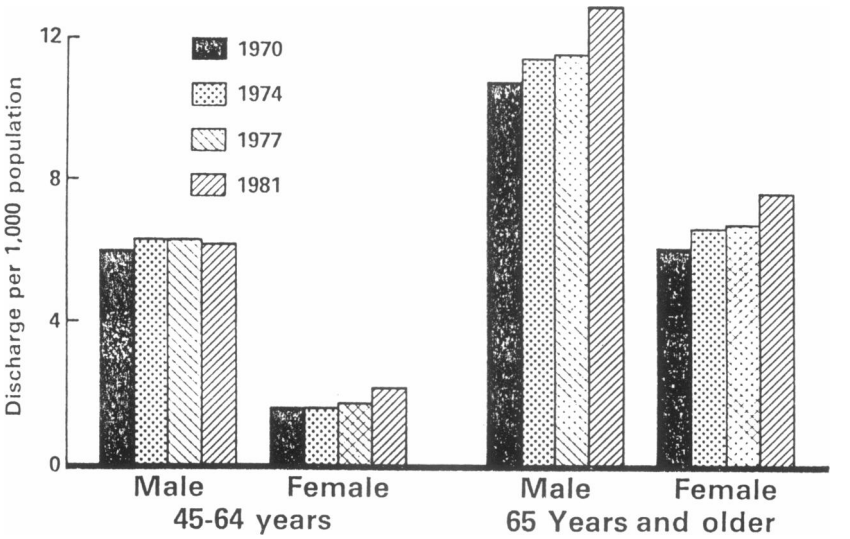

Fig. 6. Hospital discharge rate for acute myocardial infarction

slight but definite improvement in survival is seen.

Other data on the incidence of myocardial infarctions are available from studies done by the Kaiser-Permanente Health Plan and from the Mayo Clinic.[6,7] The four sources are split: two show stable rates of incidence and even an increase, and two show a decline. Far more data are needed to decide this issue.

Improvement in Medical Care

What other factors might affect survival from coronary heart disease? Earlier diagnosis, improved diagnosis, improved prehospital treatment such as emergency medical care services, improved hospital treatment with coronary care units and monitoring for very effective treatment of heart disease in the first few critical hours, a wide variety of other procedures including bypass surgery, and the increased availability and use of medical services. Almost any clinician, public health worker, or provider of medical services will agree that all of these factors have probably improved during the last 30 years, but to document the effect that these have had upon survival from heart disease is very difficult.

Some available data show, for example, improvement during the 1970s in the use of coronary care units and intensive care units.[5] Unfortunately, no data prior to 1970 are available for comparison with the years when

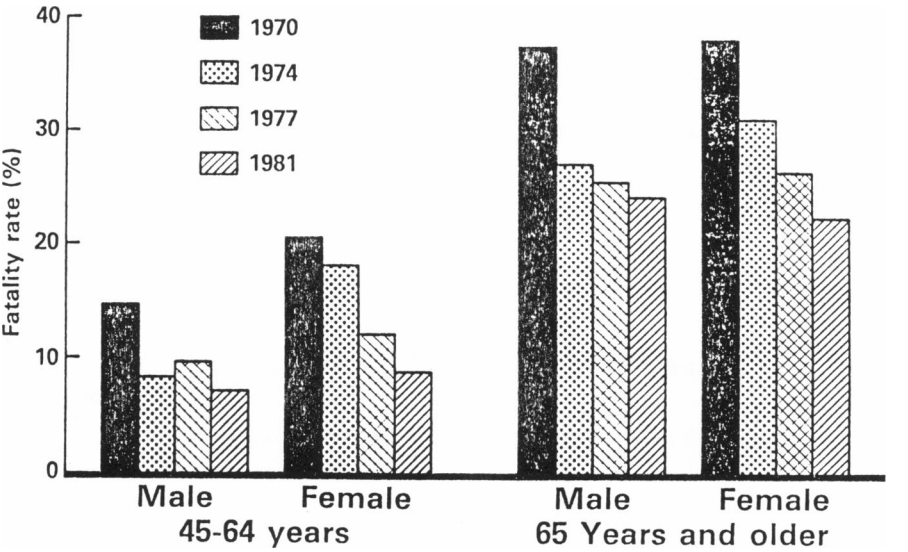

Fig. 7. Hospital fatality rate for acute myocardial infarction

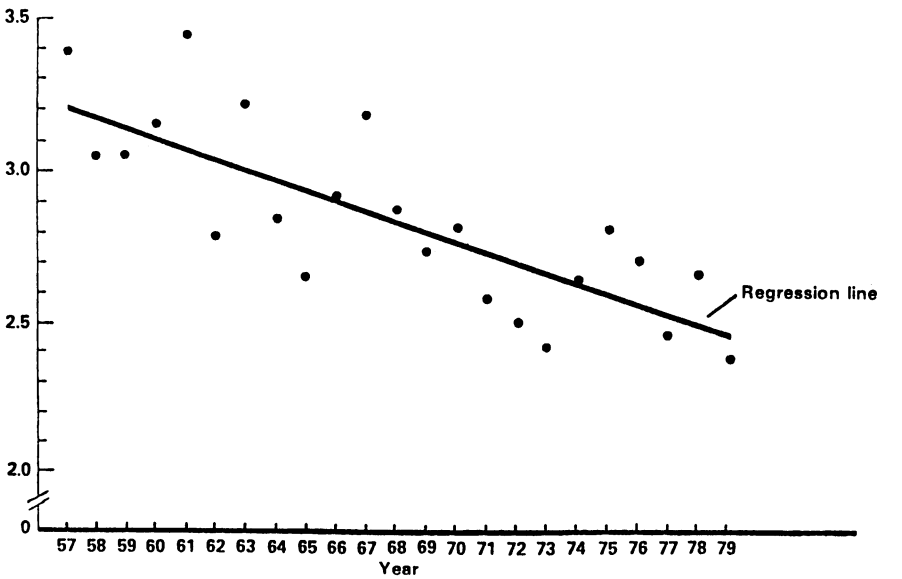

Fig. 8. Age-adjusted incidence rates of MI. Dupont Company, male employees

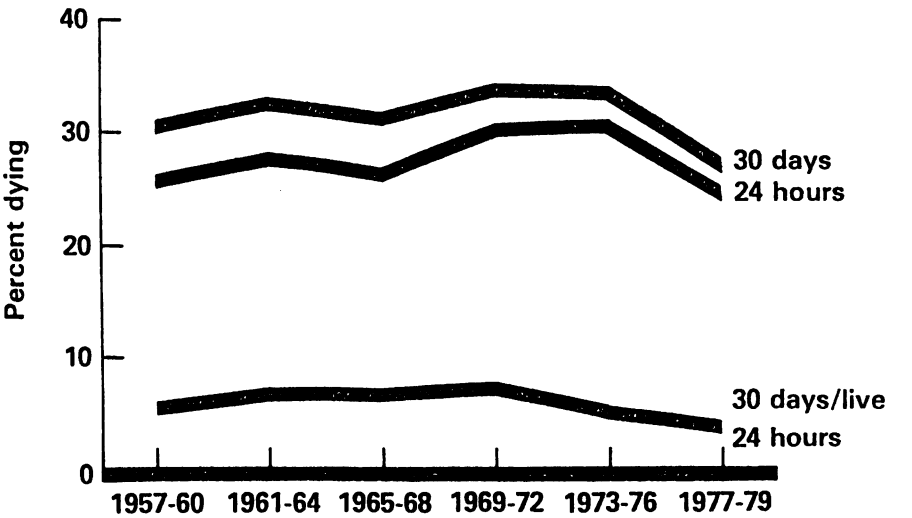

Fig. 9. Case fatality rates. Dupont Company, all male cases

coronary care units were coming into existence. But in 1970 the Professional Activity Survey found that nearly 60% of coronary patients were already being treated by the best available acute coronary care technology, 38% in coronary care units and 21% in intensive care units. By 1977 nearly 60% were treated in coronary care units and 22% in intensive care units. More than 80% of all patients hospitalized for acute myocardial infarction were receiving what was believed to be the most effective, technologically best, medical care.

Another index of progress during these years is the changes in the numbers of cardiovascular operations and procedures. According to unpublished data from the National Hospital Discharge Survey, by 1970 more than 500,000 cardiovascular procedures were being done—16,000 valves were implanted, 14,000 by-pass operations, 37,000 pacemakers, 77,000 catheterizations. By 1981 nearly one and a half million cardiovascular procedures were performed annually—nearly 160,000 coronary bypass operations, 176,000 pacemakers, 400,000 catheterizations—a tremendous increase in the number of technologically sophisticated procedures to treat and care for cardiovascular patients.

Improvements Through Prevention

Age, sex and race are important factors in heart disease. Socioeconomic factors and genetic factors also play a role, but these by and large are

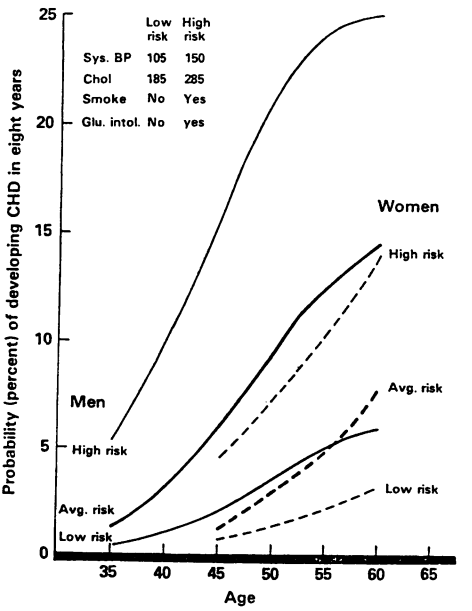

Fig. 10. Probability of developing CHD in eight years by age, sex, and risk category

uncontrollable, and prevention has concentrated on traditional risk factors for heart disease—elevated cholesterol, high blood pressure, cigarette smoking, diabetes mellitus, and obesity.[9] These have been the subjects of major clinical trials and preventive measures, and considerable evidence exists for their role in heart disease. Other factors—psychological, behavioral, and a wide variety of dietary, environmental, and biochemical factors—have been investigated, but the evidence for these is not nearly as direct as for traditional risk factors. An example of how useful traditional risk factors are in predicting coronary heart disease is shown in Figure 10, using data from the Framingham Heart Study. This shows by age groups for men and for women the probability of developing coronary heart disease in eight years. The average 35-year-old man has about a 2% chance of developing heart disease during the subsequent eight years, whereas at the age of 60 he has about a 13% chance. Women have about the same risk displaced by about 10 years. However, when we categorize the population in terms of major risk factors—systolic blood pressure, cholesterol, smoking, and glucose intolerance—into a low risk group and a high risk group, the spread in the prediction of the risk to the individual is much greater, almost an eightfold difference between the high risk

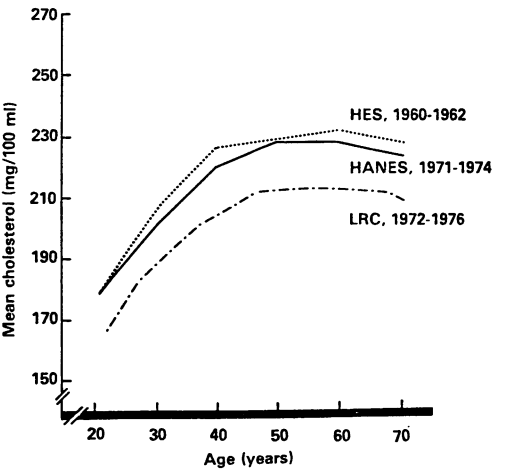

Fig. 11. Mean cholesterol levels of white males by age and year of examination. Comparison of HES,* HANES,* AND LRC† values.* Serum cholesterol values. †Plasma cholesterol values, which average about 3% lower than serum cholesterol values.

group and the low risk group at any age. At age 55 a high risk man with all four risk factors would have about one chance in four of a heart attack during the following eight years; if he did not have these risk factors, he would have only a 5% risk—about the same as a woman of that age. The same risk factors also apply to women, though displaced again by about 10 years.

What is the evidence that improvements in these risk factors have led to a decline in the mortality from coronary heart disease? Data on mean cholesterol levels are available from three surveys conducted during the 1960s and 1970s: the National Health Examination Survey and the National Health and Nutrition Examination Survey, conducted by the National Center for Health Statistics, and the Lipid Research Clinics Program, which is essentially comparable but not done on a truly random sample of the population.[10,11] The data (Figure 11) show a decline from 1960 to the late 1970s at every age in the mean level of serum cholesterol. It is perhaps a modest decline, amounting to only about 5%, but it is statistically large enough to account for a portion of the decline in mortality. For hypertension, progress is greater. During the early 1960s only about one in six hypertensive patients were aware of and adequately treated for their hypertension. Nearly half of the hypertensive population did not even know that they had hypertension. The situation was essentially the same in 1971 just before the National Institutes of Health embarked on the High

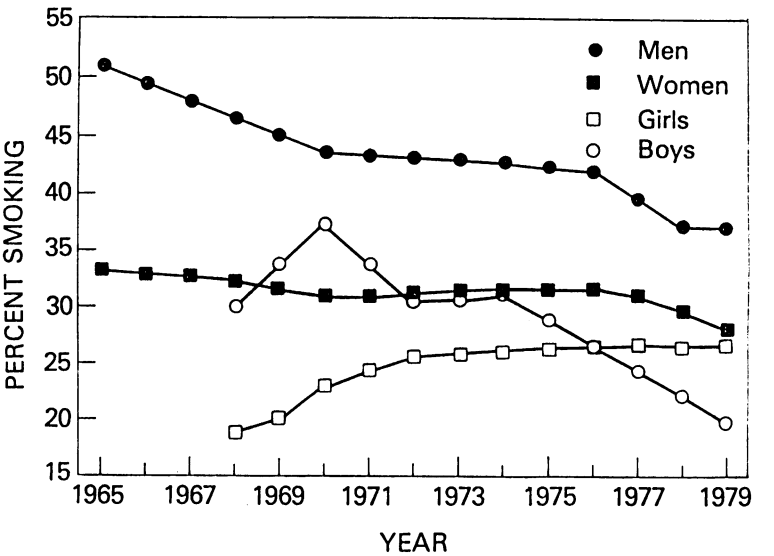

Fig. 12. Percent of population smoking

Blood Pressure Education Program. By 1974, after the program had been in effect for only two or three years, there had been almost a 50% increase in the hypertensive patients being adequately treated and almost a halving of the proportion of the hypertensive population who did not know that they had hypertension. More recent data indicate that this trend has continued.[12] Particularly in the black community, which has taken on hypertension as a particular challenge, there has been fantastic improvement in the diagnosis and effective treatment of hypertension and therefore a decline in the incidence of heart disease and, even more important, of stroke.

Since the first Surgeon General's Report on Smoking appeared in 1964, the proportion of people who smoke has declined (Figure 12).[13] More than half of the men in the United States smoked cigarettes in 1965; by 1979 just over one third currently smoked. However, women continued to smoke at essentially their pre-Surgeon General's Report rate until fairly recently. The latest surveys indicate a beginning decline among women. Among boys and girls, boys got the message first, toward the latter part of the 1960s. Since then it has been a very gratifying experience to observe that teen-age boys have not been taking up the cigarette smoking habit as rapidly as their fathers did. For girls though, the story is not as optimistic. Relatively few high school girls were cigarette smokers before 1970, but

in the 1970s their rate of smoking increased and now more teen-age girls than boys smoke. Very recent data indicate that the increase among girls may be leveling off, but it is too early to tell.

When these trends in smoking, cholesterol, and blood pressure are translated into some of the mathematical equations that relate risk of dying from heart disease to these risk factors, we get the following phenomenon. Just using the 5 mg/dl drop in mean cholesterol levels we would have expected a 4.3% drop in the mortality rate. A very slight drop in diastolic blood pressure of 2 mm Hg on the average would have resulted in an 8.7% decline in mortality, and a 20% drop in cigarette smoking would have resulted in a 10% drop in mortality. If all three occurred, and there is some indication that they did, we would have expected a 22% decline in mortality rates, almost exactly what was observed during the period to which the data apply.[14]

GOALS

In 1978 the National Heart, Lung, and Blood Institute held a conference to examine the decline in coronary heart disease mortality. An expert panel was asked to identify factors causing the decline and to measure their contributions. After reviewing many of the factors I have discussed, the panel concluded that there was some contribution from primary prevention, some documentable improvements in medical care, but that the reasons for most of the decline were unknown.[1] Those reasons still remain largely unknown. Of all the data presented here, no real cause and effect relationship can be documented in an experimental mode.

More than 100 years ago, William Farr, summarizing changes in mortality in England, said that "the death rate is a fact, anything beyond this is an inference." The decline in heart disease mortality is a fact—on the data available, we must make inferences and suggestions for national policy. Diseases of the heart, in spite of the downturn in mortality, still are the leading cause of death in the United States. They accounted for 38% of all deaths in 1981, about the same proportion as in 1968.

Both our own government and the World Health Organization have made suggestions and set objectives. For example, a World Health Organization expert committee has made recommendations in such areas as controlling diet and blood cholesterol levels and treating hypertension for active programs to effect changes that will improve the rates of heart disease.[15] In regard to psychological factors, alcohol consumption, drink-

ing water constituents, and the use of oral contraceptives, the WHO expert committee remarked that there is some suggestive evidence that these may play a role, but it is too early to suggest any public health measures to implement changes in these areas. The United States government has made no direct recommendations in this area as official policy, but has set goals to promote health and to prevent disease during the 1980s.[16] The goals for the year 1990 are expressed in quantitative terms so progress can be measured. Following are a few related to cardiovascular disease:

1) By 1990 the average daily sodium ingestion for adults should be reduced at least to 3-6 grams in an effort to control hypertension. In 1979, the baseline from which progress will be measured, estimated adult intake averaged between 4 and 10 grams.

2) By 1990 the prevalence of significant overweight among the American adult population should be decreased to 10 % for men and 17 % for women without nutritional impairment. In 1971-1974 14 % of men and 24 % of women were considered to be 20 % heavier than their desirable weight. The goal would cut the prevalence by about one third for both men and women.

3) By 1990 the proportion of adults who smoke should be reduced to below 25 %. In 1979 about one third of the U.S. adult population were smokers.

4) By 1990 the proportion of children and youths aged 12-18 years old who smoke should be reduced below 6 %, that is, cut the present rate in half.

5) By 1990 the mean serum cholesterol level in the adult population should be at or below 200 mg/dl, about a 10 % decline from the current level of 220 mg/dl rate.

6) By 1990 the proportion of adolescents participating regularly in appropriate physical activity, particularly fitness programs that can be carried into adulthood, should be greater than 90 %. No baseline data are available.

7) By 1990 the proportion of adults 18-65 participating regularly in vigorous physical exercise should be greater than 60 %. In 1978 that figure was only 35%. Should we have required gymnastics or jogging for medical students to perpetuate the idea of regular physical exercise?

Thus, the implications of the decline in coronary heart disease have been taken very seriously. At the National Center for Health Statistics we shall continue to document the trend in mortality and to follow the trend in incidence as far as we can from the National Hospital Discharge Survey,

and conduct special surveys to monitor the changes in risk factors. It will be up to the public health community and the biomedical community at large to make sure that these objectives are achieved and that the decline in mortality from heart disease continues to the year 2000.

REFERENCES

1. Havlik, R. J. and Feinleib, M., editors: *Proceedings of the Conference on the Decline in Coronary Heart Disease Mortality*. Bethesda, October 24-25, 1978, U.S. Department of Health, Education and Welfare. DHEW Report No. (NIH) 79-1610, May 1979.
2. Feinleib, M. and Rifkind, B. M.: Changing patterns of cardio-vascular mortality in the United States. *Isr. J. Med. Sci. 18*:1098,1982.
3. Feinleib, M., Havlik, R. J., and Thom, T. J.: The changing pattern of ischemic heart disease. *J. Cardiovasc. Med. 7*:139,1982.
4. World Health Statistics: *Annual Mortality Statistics for the Years 1969-1978*. Geneva, World Health Organization.
5. National Center for Health Statistics: *Utilization of Short-Stay Hospitals: Annual Summary for the United States for the years 1970-1980* and unpublished data. Hyattsville, Md., Public Health Service.
6. Friedman, G. D.: Decline in Hospitalizations for Coronary Heart Disease and Stroke: the Kaiser-Permanente Experience in Northern California, 1971-1977. In: *Proceedings of the Conference on the Decline in Coronary Heart Disease Mortality,* Havlik, R. J. and Feinleib, M., editors. Bethesda, October 24-25, 1978, U.S. Department of Health, Education and Welfare. DHEW Report No. (NIH) 79-1610, pp. 109-115.
7. Elveback, L. R.: Coronary Heart Disease in Rochester, Minnesota, 1950-1975: Incidence and Survivorship. In: *Proceedings of the Conference on the Decline in Coronary Heart Disease Mortality,* Havlik, R. J. and Feinleib, M., editors. Bethesda, October 24-25, 1978. U.S. Department of Health, Education and Welfare. DHEW Report No. (NIH) 79-1610, pp. 116-123.
8. Pell, S. and Fayerweather, W. E.: Morbidity trends in myocardial infarction in a large employed population, 1957-1979. *Am. Heart Assoc. CVD Epidemiol. Newsletter 31*:56, 1982.
9. Kannel, W.B., McGee, D., and Gordon, T.: A general cardiovascular risk profile: The Framingham Study. *Am. J. Cardiol. 38*:46,1976.
10. Abraham, S., Johnson, C., and Carroll, M.: *Total Serum Cholesterol Levels of Adults 18-74 Years, United States 1971-1974*. Vital and Health Statistics. Series 11, No. 205. DHEW publication No. (PHS) 78-1652. Washington, D.C., Govt. Print. Off., 1978.
11. Stamler, J.: Population Studies. In: *Nutrition, Lipids, and Coronary Heart Disease,* Levy, R. I., Rifkind, B. M., Dennis, B. H., and Ernst, N. D., editors. New York, Raven, 1979, pp. 25-88.
12. National Center for Health Statistics, Rowland M. and Roberts, J.: *Blood Pressure Levels and Hypertension in Persons Ages 6-74 Years: United States, 1976-80*. Advance Data from Vital and Health Statistics, No. 84. DHHS Pub. No. (PHS) 82-1250. Hyattsville, Md., Public Health Service, 1982.
13. National Center for Health Statistics: *Health, United States, 1982*. DHHS Pub. No. (PHS) 83-1232. Public Health Service, Washington, D.C., Govt. Print. Off., 1982.
14. Beaglehole, R. et al.: Secular Changes in Blood Cholesterol and Their Contribution to the Decline in Coronary Heart Disease Mortality. In: *Proceedings of the Conference on the Decline in Coronary Heart Disease Mortality,* Havlik, R. J. and Feinleib, M., editors. Bethesda, October 24-25, 1978, U.S. Department of Health, Education and Welfare. DHEW Report No. (NIH) 79-1610, pp. 282-295.
15. WHO Expert Committee: *Prevention of Coronary Heart Disease*. WHO Technical Report Series 678, 1982.
16. Department of Health and Human Services: *Promoting Health/Preventing Disease: Objectives for the Nation*. Washington, D.C., Public Health Service, 1980.